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ORIGINAL ARTICLE

Characterization of the Walch B3 glenoid in primary osteoarthritis

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Background: The type B3 glenoid is an addition to the Walch classification. A potential etiologic theory is that it is a progression of the B2. It is characterized by uniconcavity, absent paleoglenoid, medialization, retroversion, and subluxation. The purpose of this study was to describe the morphology of B3 glenoids.
Methods: Fifty-two patients with B3 glenoids underwent 3-dimensional analysis of computed tomography data. Glenoid measurements (retroversion, inclination, medialization) and humeral head subluxation according to the scapular and glenoid planes were determined. The measured variables were compared between male and female patients.
Results: The mean B3 retroversion, inclination, and medialization were 24° ± 7°, 8° ± 6° superior, and 14 ± 4 mm, respectively. The mean posterior subluxation was 80% ± 8% and 54% ± 6% according to the scapular and glenoid planes, respectively. There were no differences in B3 characteristics between sexes ($P > .05$). A significant correlation existed between glenoid retroversion and humeral head subluxation relative to the scapular plane, with every 1° increase in retroversion translating to a 1% increase in subluxation ($P < .001$). In contrast, when referencing the glenoid plane, the humeral head remained concentric to the erosion.
Conclusions: The B3 is uniconcave and retroverted. As glenoid retroversion increases, posterior humeral head subluxation significantly increases as referenced to the scapular plane; however, when referenced to the glenoid plane, the head remains concentric to the erosion. This appearance of "concentricity" is acquired secondary to the wear pattern, creating a uniconcave glenoid. Therefore, surgeons should be aware that the visualized concentricity is a product of the erosion pattern and thus may conceal a greater amount of subluxation potential.
Level of evidence: Anatomy Study; Imaging

Keywords: Osteoarthritis; B2; biconcave; shoulder arthroplasty; retroversion; posterior subluxation; B3

Investigations performed at the Mechatronics Laboratory of the Roth|McFarlane Hand and Upper Limb Center, St. Joseph's Health Care, Western University, London, Ontario, Canada.
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Accurate preoperative assessment of glenoid morphology is important during shoulder arthroplasty. In primary glenohumeral osteoarthritis, it is common to encounter posteroinferior glenoid erosion, glenoid retroversion, and posterior subluxation of the humeral head. Failure to identify and to address

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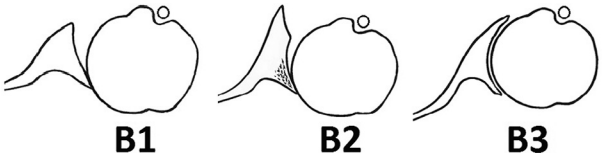

Figure 1 The Walch type B pattern of glenoid wear has the hallmark feature of posterior humeral head subluxation.[15] The type B1 is described as posterior humeral head subluxation with minimal glenoid erosion. The type B2 glenoid also has posterior humeral head subluxation; however, it has posteroinferior glenoid wear with a characteristic biconcave appearance. The B3 glenoid, which is a recent addition to the Walch classification,[1] has been theorized to be a progression of the B2 deformity. It is characterized by uniconcavity, retroversion, posterior humeral head subluxation, and medialization.

these glenoid abnormalities during surgical reconstruction may threaten the long-term survivability of standard polyethylene components.[5,7,9,13] In addition, differing glenoid morphology patterns have been associated with different natural histories, which may lead a surgeon to select one type of implant over another.[4,12]

In 1999, Walch et al[15] classified glenoid morphology into 3 types. The type A pattern has a concentric glenohumeral joint with minor (A1) and major (A2) glenoid wear. The type B pattern has the hallmark feature of posterior humeral head subluxation. The type B1 is described as posterior humeral head subluxation with minimal glenoid erosion. The type B2 glenoid also displays posterior humeral head subluxation; however, it has posteroinferior glenoid wear due to edge loading from the subluxated humeral head. The B2 glenoid has a characteristic biconcave appearance on an axillary radiograph or axial computed tomography (CT) images. The newly eroded posterior facet of the B2 has been termed the neoglenoid. The anterior facet, which represents the original glenoid articular surface, has been termed the paleoglenoid.

A modification to the original Walch[15] classification has recently been proposed with the addition of the B3 morphology[1] (Fig. 1). The B3 glenoid has been theorized to be a progression of the B2 deformity. In the B2 glenoid, as wear progresses, the neoglenoid becomes a larger portion of the glenoid face (Fig. 2). Correspondingly, the paleoglenoid becomes smaller. Eventually, the humeral head wears away the entire paleoglenoid, converting the glenoid morphology from biconcave to uniconcave with the glenoid face represented entirely by the neoglenoid. Presently, there is little literature on the characteristics of the B3 glenoid.[1] Thus, the purpose of this CT-based study was to evaluate the clinical and morphologic characteristics of B3 glenoids.

Materials and methods

The shoulder arthroplasty databases of 2 institutions were examined to identify patients with a type B3 glenoid morphology.

Table I Patient characteristics

B3 cohort characteristics	
Age	72 ± 8 years
Gender	22 male, 30 female
Side	39 right, 13 left

A type B3 morphology was defined as >15° of retroversion, a uniconcave appearance, or at least 70% posterior humeral head subluxation in a shoulder with glenohumeral osteoarthritis.[1] Each patient was classified according to the modified Walch classification by 1 of 2 experienced shoulder surgeons (G.W., G.S.A.), and all patients with a B3 glenoid morphology were identified. Patients with rotator cuff tear arthropathy, inflammatory arthritis, and posttraumatic arthritis were excluded. The B3 study cohort therefore consisted of 52 patients with a mean age of 72 ± 8 years (range, 57-87 years). There were 22 male and 30 female patients; 13 left and 39 right shoulders were included (Table I).

Each patient's preoperative shoulder CT scan Digital Imaging and Communications in Medicine (DICOM) data were uploaded to a validated 3-dimensional (3D) imaging software (Glenosys; Imascap, Brest, France).[11,16] CT scans were excluded if they did not include the entire scapula. The DICOM data were segmented into 3D images of the glenoid, scapula, and humeral head. A mathematical algorithm was used to calculate glenoid version, inclination, and medialization. In addition, posterior humeral head subluxation according to the scapular plane and according to the glenoid plane was calculated. Glenoid retroversion was calculated as the spherical orientation of the glenoid fossa in the horizontal plane in regard to the scapula reference plane. To determine this angle, the best-fit sphere was adjusted to the glenoid surface, and the angle between the glenoid sphere centerline and the scapular plane projected on the transverse axis of the scapula (horizontal plane) was computed (Fig. 3, *A*). Glenoid inclination was calculated as the spherical orientation of the glenoid fossa in the scapular plane. It was determined as the angle between the glenoid centerline and the vertical plane of the scapula (Fig. 3, *B*). The percentage of posterior humeral head subluxation according to the scapular plane was calculated by dividing the 3D posterior volumetric portion of the humeral head by the whole volume of the humeral head (Fig. 4). This 3D measurement eliminates the variability in 2-dimensional axial slice selection. Humeral head subluxation according to the glenoid plane was calculated as described by Walch et al (Fig. 4, *C*).[15] Humeral head subluxation was reported as a percentage of the humeral head posterior to the respective planes. For example, in a concentrically reduced joint, humeral head subluxation was 50%, as half of the humeral head is posterior to the central glenoid or scapular plane (Fig. 4, *C*). Finally, the amount of glenoid medialization was calculated in millimeters by measuring the maximum depth, perpendicular to the scapular plane, from the anterior rim of the eroded glenoid to the posterior rim.

In addition to reporting descriptive measurements for the B3 cohort, we compared glenoid variables between male and female patients and between younger (≤65 years old) and older patients. Statistical analyses were performed using SPSS (IBM Corp., Armonk, NY, USA). Descriptive parameters were reported as means and standard deviations. Continuous variables were compared using Student *t*-test with the *P* value adjusted using the Bonferroni correction. Linear regression was also used to determine the correlation between glenoid